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Research paper

Investigation of Interaction Features of Oil Emulsions and Sorption Material Based on Beet Processing Waste

Tatiana R. Denisova[1], Munir N. Miftahov[1], Svetlana V. Sverguzova[2], Zhanna A. Sapronova[2], Mikhail N. Spirin[2]

[1]Kazan Federal University
[2]Belgorod State Technological University
**Corresponding author E-mail: timiryanova.tanya@yandex.ru*

Abstract

Research results of interaction features of model water emulsions of edible oils with the sorption material received on the basis of carbonate-containing withdrawal of processing of sugar beet are given in work. The Carbonation sludge which is formed in the course of beet sugar production was exposed to heat treatment at a temperature of 600 °C for carbonization of the organic substances which are available in its structure for the purpose of material sorption characteristics improvement. It is established that interaction of sorption material with model emulsions of edible oils is carried out at the expense of adsorption forces, the lack of influence of structural features, such as presence of functional groups (-IT, as in case of ricinoleic acid) and lengths of a carbon chain of molecules of fatty acids on intensity of sorption interaction with sorption material is proved. The isotherms constructed on the basis of experimental data demonstrate monomolecular adsorption of oils on a surface of the modified carbonation sludge. Values of sorption capacity for the studied material are: 182 mg/g for sunflower oil; 184 mg/g for soy oil and 189 mg/g for olive. It is defined that adsorption of oils happens within the first 10-20 minutes then the active centers of the thermally modified carbonation sludge are sated.

Keywords: *edible oils, model water oil emulsions, cleaning, sorption material, carbonation sludge, adsorption isotherm.*

1. Introduction

Environmental pollution continues to progress. Around the world water objects experience enormous technogenic strain that everything leads to destruction of new ecosystems [1-8].
At the same time, the developed economic situation demands minimization of expenses therefore search of new inexpensive materials and ways for sewage treatment is an important task.
Recycling of waste of the industry is direct expression of the concept of rational environmental management at which there is a minimization of impact on the surrounding environment [9-13]. Now in the world community the new innovative direction in the field of environmental protection - use of waste of industrial and agricultural production as reagents for purification of waste and natural waters of various pollutant promptly develops.
On a number of industrial productions large-tonnage waste which are involved in secondary processing only partially, but, owing to the physical and chemical properties are formed, can be used in processes of removal of pollutant from natural and sewage. Firm carbonate-containing withdrawal of production of sugar from sugar beet (a carbonation sludge), so-called "defecate", formed in the course of beet sugar production belongs to one of such waste.
The mineralogical structure of the initial defecate defined by the X-ray phase analysis (figure 1) is presented, generally $SASO_3$ (75-78%) what existence of the corresponding peaks of d (A) = 3,875 testifies to; 3,048; 2,505; 2,290; 1,922; 1,881, SiO_2 impurity (d (A) = 3,389) and clay minerals are fixed (d (A) = 10,464; 7,081; 6,281). Primary deposit also contains about 20% of organic substances in the structure.

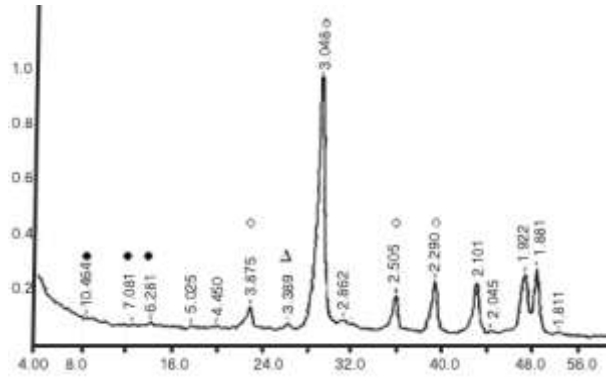


Fig. 1:. Diffraction pattern of initial filter-press cake: ○ - $SASO_3$; Δ - SiO_2; ● - clay minerals

As the initial carbonation sludge contains impurity of organic substances, roasting was applied to their removal at temperatures from 200 to 1000 ° C. As a result of roasting organic substances charred, forming a carbon layer on the surface of sorption material. By the made experiments it is defined that the best sorption characteristics at extraction of various pollutant were observed at the thermally modified carbonation sludge (TMCS) subjected to roasting at a temperature of 600 ° C (TMCS600) [14-17].
Some physical and chemical indicators of $TMCS_{600}$ given in table 1 are defined.

Table 1:. TMCS600 physicochemical characteristics

Characteristic	Unit of measure	Value
True density	kg/m^3	2720
Median particle size	μm	2-5

Specific surface area	m^2/g	82
Total void space	cm^3/g	0,4117
Contact angle	degree	130
pH of aqueous extract	-	9,8
Adsorption capacity of methylene blue	mg/g	77,9

Proceeding from structure and physical and chemical $TMCS_{600}$ properties, it is assumed that the last has to show good sorption properties concerning edible oils, such as sunflower, soy, linen, etc. that was confirmed with primary researches (figure 2). The essence of researches consisted in processing of an oil-containing emulsion sorption material - $TMCS_{600}$ with the subsequent office of a deposit filtering. The deposit which is dried up at a temperature of 105 °C was subjected to the analysis by means of an infrared spectophotometery for detection of the traces of oil on the surface of sorption material taken in the course of cleaning.

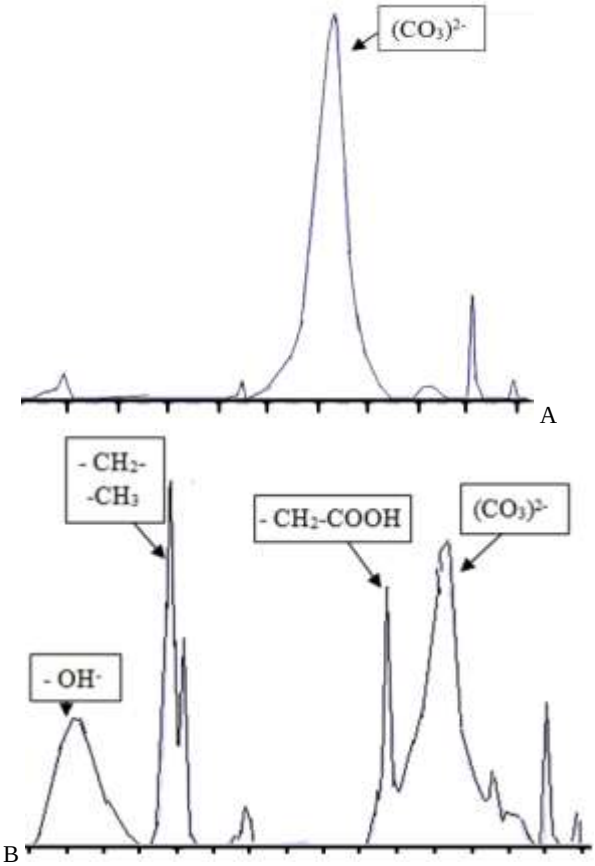


Fig. 2:. Infrared spectra: a) $TMCS_{600}$, b) $TMCS_{600}$ with adsorbed olive oil

The results presented in the figure 2 show that there is an extraction of oils the material $TMCS_{600}$ from model emulsions as at IR spectrum of slime of water purification there are peaks characteristic of C=O of groups of carbonic acids (1700-1800 cm^- 1) and also metil and methylene groups (2800-2900 cm^- 1).

For determination of rational parameters of carrying out processes of water purification and management of influence of various factors on efficiency of extraction of oils from the water environment, it is necessary to obtain information on the nature of interaction of components.

METHODS

Model emulsions prepared by emulsification of oils in the distilled water. In the capacity containing 0,5 dm^3 waters, with water were brought by 250 mg of oil and contents of a vessel mixed up on the electronic mixer with a speed of 400 rpm during 24 h. Steady fine emulsions of oils in water were as a result formed.

Determination of initial and residual turbidity of emulsions was carried out on the turbidimeter of the HI 98703 brand.

The indicator of the chemical consumption of oxygen (CCO) in model emulsions takes place by means of the HPK photometric analyzer of brand "Ekspert-003-HPK".

2. Results and Discussion

The first stage of researches was definition of existence or lack of coagulative processes in system. For this purpose KCL electrolyte was added to the studied emulsion of oils in water x. h at the rate of 22,3 g on 1 dm^3 emulsions then the cleaning efficiency of oils was estimated (on initial and final HPK values of a model emulsion).

The made experiments allowed defining that addition of electrolyte does not lead to coagulation of drops of oil in the water environment what low indicators of cleaning of model systems (figure 3) testified to.

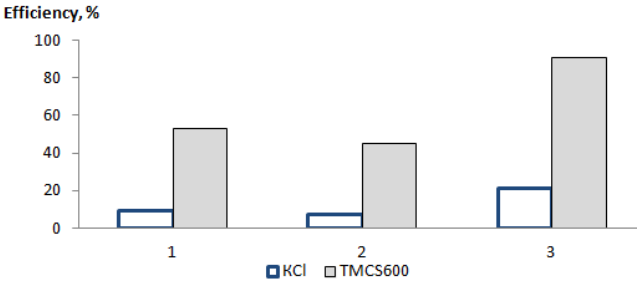
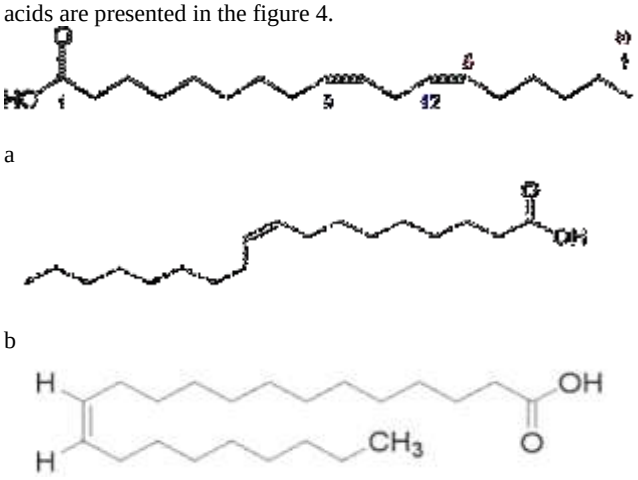


Fig. 3:. The comparison of water treatment efficiency when adding electrolyte and sorption material: 1 - olive oil; 2 - soybean oil; 3 - sunflower oil. The settling time - 15 min. The initial concentration of oils is 500 mg/DM^3; addition of sorption material - 2 g/DM^3, KCl - 0.3 mol/DM^3.

The edible oils received from different oil-bearing crops differ in the percentage of the fatty acids which are a part of triglycerides [18-21]. As the chemical structure of their molecules has the specific features caused by existence or lack of double communications and their quantity in the subsequent influence of structural features of the fatty acids which are a part of edible oils on efficiency of catching of particles of the last by sorption material from emulsions was estimated.

In this regard, a series of experiments with sunflower, linen, castor and mustard oils as having obvious differences in a structure of the prevailing fatty acids was conducted.

So, linseed oil has the greatest percentage of nonsaturated communications - is its part up to 60% of linolenic ($C_{17}H_{29}COOH$) and up to 30% linoleic acids ($C_{17}H_{31}COOH$). Contain in sunflower oil, generally linoleic and olein acids, mustard oil contains about 50% of erucic acid ($C_{21}H_{41}COOH$) and also up to 30% of oleic acid, castor oil contains up to 90% of ricinoleic acid, ($C_{17}H_{30}OHCOOH$) [18-21]. Structural formulas of the specified acids are presented in the figure 4.



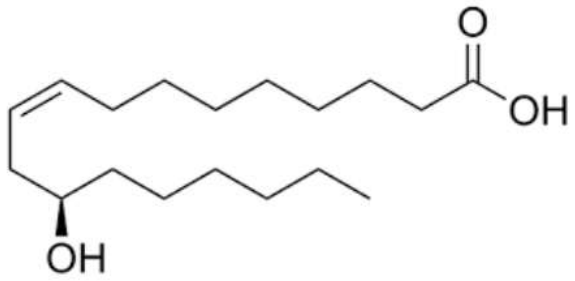


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Fig. 4:. Structural formulas of fatty acids: linoleic, b) oleic, c) erucic, d) ricinoleic acid

Research results of model emulsions cleaning efficiency of various oils with use of $TMCS_{600}$ are presented in table 2 (time of interaction of 10 minutes) and in the figure 4 (interaction time 1 hour). Solution temperature - 20 °C, initial concentration of oils - 250 mg/dm^3, the cleaning efficiency was estimated on change of turbidity of the environment.

Apparently from the submitted data, the cleaning efficiency of model emulsions of various edible oils remains approximately identical that indicates lack of influence of structural features, such as presence of functional groups (-IT, as in case of ricinoleic acid) and lengths of a carbon chain of molecules of fatty acids on intensity of sorption interaction from $TMCS_{600}$.

Table 2:. Treatment efficiency of various oil emulsions by $TMCS_{600}$

No	Oil	$TMCS_{600}$ additive, g/dm^3	Treatment efficiency, %
1	Sunflower	10	90.8
2		20	94.5
3	Mustard	10	85.4
4		20	89.2
5	Castor	10	89.1
6		20	95.3
7	Linseed	10	88.3
8		20	94.1

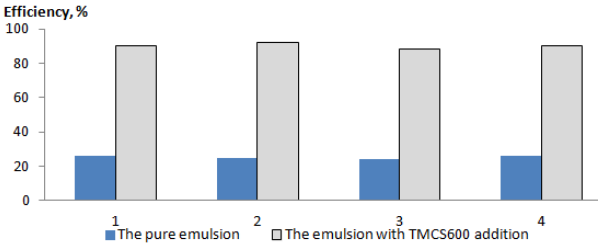

Fig. 5:. The emulsions treatment after 1 hour of settling. Oils: 1 - sunflower; 2 - mustard; 3 - castor; 4 - linen

As, after 10 minutes of interaction of sorption material with model emulsions, indicators of cleaning efficiency almost do not differ from received after 1 hour, adsorption of oils happens within the first 10-20 minutes then the TMCS active centers are sated.

For determination of size of sorption capacity of $TMCS_{600}$ in relation to vegetable oils, isotherms of adsorption of the last are constructed (figure 6). Researches of process of adsorption were conducted in the static mode.

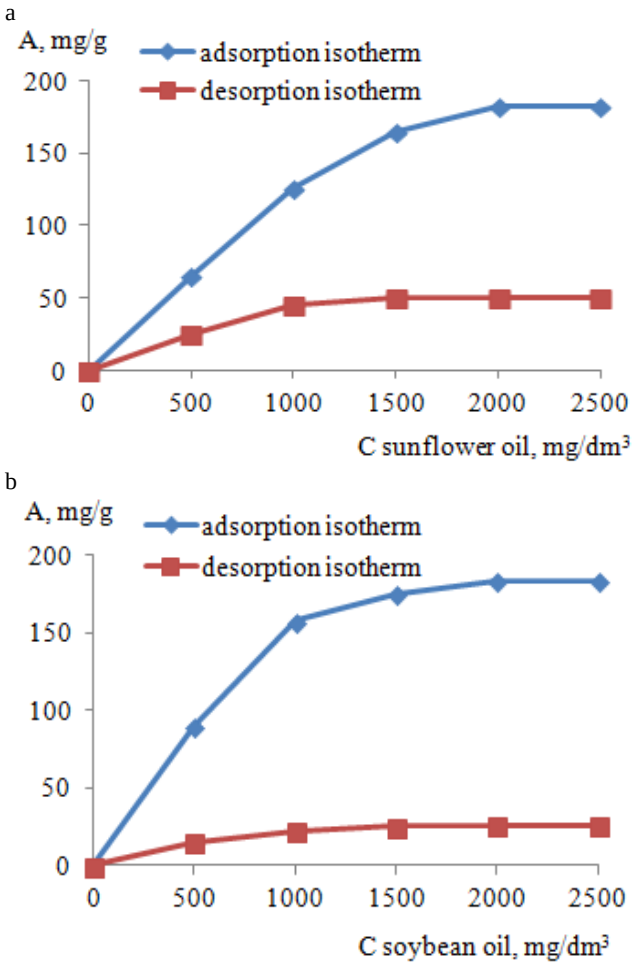

Fig. 6:. The adsorption and desorption isotherms of sunflower (a) and soybean (b) oils on the TCMS surface

The form of the received isotherms demonstrates monomolecular adsorption as has only one bend then there occur saturation of sorption material and the curve forms the plateau. By the made experiments it is defined that values of sorption capacity for the studied material are: 182 mg/g - for sunflower oil; 184 - mg/g for soy oil and 189 mg/g - for olive.

3. Summary

During the conducted researches it is established that interaction of sorption material ($TMCS_{600}$) and model emulsions of vegetable oils happens due to adsorption. At the same time, influence of structural features, such as presence of functional groups and length of a carbon chain of molecules of fatty acids on intensity of sorption interaction from $TMCS_{600}$ is insignificant. The adsorptive interaction in system happens within 10-20 minutes then there occurs saturation of the active centers of a sorbent.

4. Conclusion

Thus, features of interaction of sorption material on the basis of carbonate-containing withdrawal of processing of sugar beet - the thermo-modified carbonation sludge subjected to roasting at a temperature of 600 are investigated ° C, - and model emulsions of various edible oils. Adsorption has monomolecular character, values of sorption capacity for the studied material are: 182 mg/g - for sunflower; 184 mg/g - for soy and 189 mg/g - for olive oils.

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